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AUTHOR Sustik, Joan M.; Brown, Bobby R.
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ABSTRACT

Assessments were made of the impact of various overt response modes on the problem-solving process. The Luchins Water Jar Problems were presented to undergraduate university students via interactive cathode ray tube computer terminals under four response mode conditions: Mnemonic Code, Multiple Choice (MC), Numerical List, and Constructed Response (CR). Initially, the List and CR modes were least susceptible to mechanization. Overall, the MC mode produced the least mechanized and most efficient performance. The CR mode group spent the greatest time in problem solving without exhibiting superior performance. Analysis of item by mode interactions revealed that across modes the problems were not of equal difficulty. Implications of response modes in problem solving and the design of instructional materials are discussed. (Author/CMV)

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RESPONSE MODE EFFECTS ON COMPUTER BASED PROBLEM SOLVING

Joan M. Sustik

Bobby R. Brown

University of Iowa

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Abstract

The Luchins Water Jar Problems were presented Ss via interactive CRT computer terminals under four response mode conditions: Mnemonic Code, Multiple Choice (MC), Numerical List, and Constructed Response (CR). Initially, the List and CR modes were least susceptible to mechanization. Overall, the MC mode produced the least mechanized and most efficient performance. The CR mode group spent the greatest time in problem without exhibiting superior performance. Analysis of item by mode interactions revealed that across modes the problems were not of equal difficulty. Implications or response modes in problem solving and the design of instructional material are discussed.

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RESPONSE MODE EFFECTS ON COMPUTER BASED PROBLEM SOLVING[1,2]

INTRODUCTION

Merging technology often leads us to look again at established research areas with different interests and enhanced precision. Working toward standard educational goals using Computer Assisted Instruction (CAI) is one context in which traditional areas of research, such as problem solving, assume new dimensions due to the characteristics of the medium.

CAI allows student input to assume varied formats or "response modes" such as light pen, touch panel, 'joy stick' or matching crosshairs as well as the more commonly used keyboard based modes such as constructed response, multiple choice or alphanumeric code. As such, response mode constitutes an instructional variable controllable by the instructional designer which may effect learning outcomes.

To date, most response mode investigations have been based on Programmed Instruction (PI) rather than CAI. These have generally investigated two covert modes, reading a PI text or reading and thinking an answer, and two overt modes, constructed response or multiple choice. In general, the constructed response mode resulted in superior performance with material which was technical or unfamiliar (Tobias, 1973). Tobias attributed the lack of response mode studies in CAI to the presumption that CAI automatically employ overt modes, not only to justify costs, but to capitalize on

the unique response and adaptive capabilities of the medium as well. In view of the numerous overt modes in use in CAI, the potential effects that these response modes may have on a variety of learning outcomes merits attention.

Most response mode studies have used posttest achievement scores as the criterion measure. None have been addressed to the effect that various response modes may have on the development of thought processes during the instructional sequence.

The present study sought to assess the impact that overt response modes may have on the processes which evolve in problem solving. Schulz (1966) noted the importance of research on inducing positive transfer in problem solving since problem solving is pervasive in all areas of intellectual activity. It may be that in manipulating the response mode which a student uses in a CAI problem solving situation, we can and do in fact alter the amount of positive transfer which occurs. The question is, then, one of whether different response modes facilitate or hinder the thought processes required in a given problem solving situation.

The problem solving task investigated in this studty was the Luchins Water Jar Test (WJT), chosen as a vehicle to assess problem solving processes because they were established in the problem solving literature and did not require knowledge in a given content area. The measure of interest in the WJT is in "Einstellung" or

"mechanization of response". This is the phenomenon of successive repetition of a given method of solution when more direct methods are available. Some people develop a mental "set" to solve a problem in the same manner that they used previously when that solution may be less appropriate than other available solutions or, even more serously, no longer viable. For these people, the effect of prior solution, more than the task at hand, becomes a major source of difficulty. A flexible problem solver is resistant to this mechanization, and employs the most direct method of solution, regardless of previous method used.

The question arises as to whether a given response mode facilitates or hinders mechanization in problem solving. The various keyboard based response modes can be viewed as a form of communication, or language, which the student uses to interact with the instructional program. Response modes may possibly serve to transmit the messages which result from the thought processes; they may, however, serve to structure the thought processes as well. If the latter is true, than it is necessary to determine if a given response mode influences thought processes in the same manner for all people, or if individuals vary in their facility to use a given mode. Research in second language learning indicates that there is a strong correlation between ability to extinguish set and the ability to acquire of a second language (Cummins and Gulutsan, 1975). To the extent that response mode can be conceived as an alternative language

used in the instructional dialogue between the student and the computer, then it follows that facility in using a given response mode may influence mechanization in computer based problem solving situations as represented by the WJT.

The purpose of this study was to determine if different keyboard based response modes would effect problem solving performance in a computer based problem solving situation by undergraduate students. The response modes investigated were mnemonic code (CODE), multiple choice (MC) numerical list (LIST) and constructed response (CR). It was assumed that response modes which more closely approximated natural language would be more facilitative of flexible thought and therefore lead to less mechanization in responding.

The problems in the Water Jar Series fall into one of the following three categories:

SET - solvable only by the original "B-A-2C" formula and designed to produce a mental set which predisposes the use of this method in subsequent problems

CRITICALS - solvable by the "B-A-2C" formula or by a shorter method and designed to test susceptibility to set

EXTINCTIONS - not solvable by the "B-A-2C" method, therefore requiring a shift in method to reach solution; designed to measure ability to overcome set

Mechanization in the WJT is operationally defined as the continued attempt to use in Critical and Extinction problems the method of solution which was correct in the Set problems. It was hypothesized that the Constructed

Response, Code, List and Multiple Choice would contribute to mechanized responding in an ascending order as indicated by the following:

1. There would be a positive direct correlation between mechanization and the number of "Einstellung" solutions in Critical problems.

2. There would be a positive direct correlation between mechanization and the number of no solutions in the Extinction problems resulting from inappropriate attempts to use the "Einstellung" method.

3. There would be an inverse relationship between mechanization and latency in both critical and extinction problems.

4. There would be an inverse relationship between mechanization and total time spent in Critical problems.

5. There would be a direct positive relationship between mechanization and total time spent in Extinction problems.

6. There would be a direct positive relationship between mechanization and number of steps to solution in the CR, CODE and LIST modes.

METHOD

SUBJECTS

Subjects were recruited from an undergraduate education course, Fundamantals of Audiovisual Techniques at the

University of Iowa in the Fall semester, 1976. These students participated on a voluntary basis to become acquainted with the use of computers in instruction. From three to seven students were present in each session held over a two week period. Of the 73 persons who participated, three persons failed to complete the problem sequence. Data from 6 additional students was discarded since these students did not correctly solve the last two Set problems, therefore precluding the assumption that they had in fact formed a set which would be tested in the subsequent Critical and Extinction problems. This standard is in keeping with those used in the original Water Jar studies (Luchins, 1942) and resulted in data collection for 64 students.

MATERIALS

The Luchins Water Jar Problems were presented on SuperBeehive cathode ray tube (CRT) terminals in the University of Iowa Computer Assisted Instruction Lab. For each problem the student was presented with jars of three different capacities and instructed to obtain a fourth quantity by filling, transferring or emptying the contents. A prototype is "You are given three jars, 'A', 'B', and 'C' which hold 11, 25 and 5 quarts. By measuring back and forth using only these three jars, obtain 4 quarts." This problem may be solved in the following manner: Fill jar B, pour from jar B into jar A, pour from jar B into jar C, empty jar C,

pour from jar B into jar C, the solution is in jar B. This procedure could be represented by the formula 'B-A-2C'. The problem series presented is listed in Table 1.

These problems were solved using one of four response modes:

CODE - a mnemonic code corresponding to possible steps, such as 'BIA' for 'pour the contents of B into A'

LIST - a numerical list corresponding to possible steps, such as '3' for the step 'fill jar C'

CONSTRUCTED RESPONSE (CR) - open ended natural language response

MULTIPLE CHOPICE (MC) - a list of solution equations such as 'B-A-2C' with three other possible solution equations

In all modes, a 'NO SOLUTION' option was available. A display at the top of the screen showed jar capacities and current values which were updated with each command. Students were advanced to the next problem when they successfully solved the problem or chose the No Solution option.

PROCEDURE

Student were given a 15 minute tour of the CAI Lab upon arrival, and were then given an opportunity to become familiar with the keyboard. Students were randomly assigned to one of four response mode groups: Code, Multiple Choice, List or Constructed Response. A five minute introduction to the Water Jar Problems was presented on the CRT followed by

instructions on the response mode to be employed. All subjects received the same sequence of problems which took from 20-40 minutes to complete. At the conclusion of the problem series, each participant worked through three sample CAI programs consisting of a sample from a Law module, a graphic demonstration and a math drill and practice.

RESULTS

INSERT TABLE 6 ABOUT HERE

As indicated in Table 6, the item by mode interaction for the analysis of variance of number of E type solutions in critical problems, the measure of susceptibility to set, was significant. Tests of simple effects revealed significant difference between response modes only in problem 7 where the MC group used significantly more E solutions than the List ($p<.004$) or CR ($p<.0004$) but not the Code group. From inspection of the means in Table 3 it can be seen that these results derive from an initial high use of E solutions in problem 7 by the MC group, followed by a total decline in use, as compared to more consistent performance by the other response mode groups.

INSERT TABLE 7 ABOUT HERE

The analysis of variance for the number of Direct (D) solutions in Extinction problems, the measure of ability to overcome set, also yielded a significant item by mode interaction as shown in Table 7. Between simple effects follow-up tests indicated a significant difference between response modes for problem 13 ($p<.003$). Pairwise comparisions revealed that on problem 13 the MC group employed significantly more D solutions than any of the other three groups. Within simple effects follow-up tests which were also completed, revealed significant differences between problems 9 and 13, with more D solutions in problem 9. The means and standard deviations for these data are

given by group in Table 3.

INSERT TABLE 8 ABOUT HERE

A significant item by mode interaction in the analysis of variance on Time to First Response in Criticals is shown in Table 8. Between simple effects follow-up tests indicated a significant difference between modes on response latency for items 7 and 8. Pairwise comparisons indicated that the MC group experienced a significantly longer latency than the code and List mode in these two problems.

INSERT TABLE 9 ABOUT HERE

As indicated by Table 9, the item by mode interaction on the analysis of variance for Time to First Response on Extinction Problems was not significant. The analysis of the mode main effect failed to achieve significance, while the item main effect was clearly significant. As can be seen from Table 4, latency for all modes was longer for problem 13 than for problem 9.

INSERT TABLE 10 ABOUT HERE

A significant item by mode interaction was present in the analysis of variance for Total Time in Problem for Criticals as shown in Table 10. Between simple effects follow-up tests indicated a significant difference between response modes for all critical problems. Pairwise comparisons demonstrated that the MC mode differed significantly from the other modes in all items except item 7 where the MC vs. Code comparison approached ($p<.09$) but did not reach significance. The means presented in Table 4

show the shortest time spent in the problem for MC, longest time by the CR group and similar, intermediate times by Code and List.

INSERT TABLE 11 ABOUT HERE

The item by mode interaction was significant in the analysis of variance for Total Time Spent in Problem for Extinction problems. Between simple effects follow-up tests indicated a significant difference between response modes on both items 9 and 13. Pairwise comparisons indicated that the MC group differed significantly from the CR on both problems. The comparisons between MC and both the List and Code modes approached significance in problem nine and achieved significance in problem 13. As can be seen in Table 4, the general pattern for Total Time in Problem in Criticals held for Extinctions with the shortest time displayed by the MC group, similar and intermediate times by the List and Code modes, and the longest time by the CR mode.

INSERT TABLE 12 ABOUT HERE

The MC group was omitted from the analysis of variance of the Total Number of Steps to Problem Completion since this mode did not require input on a per step basis.

As indicated in Table 12, the Item by Mode Interaction was not significant for the Analysis of Variance for Total Number of Steps in Critical problems based on the Code, List and CR modes. An examination of the mode main effect was not significant. The means displayed in Table 5 indicate

that across modes problems 7 and 11 took fewer steps than problems 8 and 10.

INSERT TABLE 13 ABOUT HERE

The Item by mode interaction on the Total Steps to completion in extinction problems failed to achieve significance as shown in Table 13. Thhe mode main effect was not significant. The analysis of the item main effect was significant, indicating that across modes there was a difference in the total number of steps to completion between items 9 and 13. Inspection of the means in Table 5 confirms the larger number of steps utilized in item 13 than in item 9.

DISCUSSION

Results failed to support the hypothesized differential susceptibility to set by the response mode groups as indicated by the use of E solutions in critical problems. Analyzing performance on the critical problems as a group, the Code and CR groups were not more impervious to set than the List and MC groups as anticipated. However, the MC group overwhelmingly utilized the E method in probem 7, an indication of set formation, but favored more direct methods in problems 10 and 11. Performance of the Code, List, and CR groups was initially superior but later inferior to MC in their use of direct methods of solution.

Similarly, the MC mode group was more consistent in overcoming set as measured by the use of Direct solutions in the Extinction problems. All four modes used the Direct

method almost exclusively in Item 9 and decreased in usage in Item 13. However, the MC group decreased to a lesser degree than did the other modes. These results appear to indicate that items 9 and 13 were not of equivalent difficulty, but that the difference in item difficulty had a more powerful effect on the Code, CR and List than on the MC mode.

Testing related to the hypothesized differental susceptiblity to set sought to determine whether more mechanized behavior would be accompanied by shorter latencies to the first response. This rests on the assumption that mechanization would preclude consideration of other methods, leading to the repetition of the first step on both Critical and Extinction problems. For the Critical series, contradictory results were found. That is, MC moved from the use of E to D solutiuons from items 7 and 8 to 10 and 11. The later use of D solutions was accompanied by shorter, not longer, latencies. The expected extra time required by the MC group when viewed in this manner manifested itself in items 7 and 8, but not in 10 and 11 where in fact the MC group exhibited the lowest mean times.

Again, contrary to hypothesized outcomes, the mode which exhibited the least mechanization in Criticals, the MC mode, took the shortest total time, while the longest totals were exhibited by the CR mode and similar intermediate times by List and Code. To an extent, one can acknowledge that in

most cases, the time to first response also constituted the the total time for the MC mode, and that long CR total reflect extended keyboard interface.

The variation in the toal time in problem on extinctions supports the previous implication that items 9 and 13 were not of equal difficulty. The means for the Code, MC and List modes were approximately twice as large for 13 as for 9, while for the CR group, the ratio was 6 times greater. However, the CR group also exhibited a large standard deviation which may indicate that a few students took considerably longer, thus inflating the mean. This may indicate that some students in the CR mode may have exhibited increased thought or hesitation from frustration when non-viable methods were attempted, behaviors less pronounced in the other modes.

The MC mode group spent less total time in problem in extinctions while maintaining less susceptibility to set. While this too may be attributed to input demands, it also may be due to differing demand characteristics of the response modes. Recognition or selection of a solution, as in the MC mode, may lead to more D solutions as well as shorter latencies than constructed responses.

Steps constituted the unit of measuring efficiency in solution, with more direct solutions defined by the use of fewer steps. Since mechanization would result in repetition of the lengthier E method, it was anticipated that mechanized modes would yield performances using a greater

number of steps. This would be amplified in the extinction problems when the attempted E method would not be viable prior to switching to another method. No significant differences as to number of steps was observed. The MC group data was not amenable to analysis on this measure.

In considering method of solution in criticals and extinctions, latency to first response and total time in problem, it appears that students using the MC mode exhibited superior performance. While the MC group showed set formation in problem 7, this quickly disappeared in following problems. The MC mode required less time in problems, and based on observation of the subjects was the easiest mode to use. No differences of note were observed between the other three groups.

Within the limitations to generilizatons due to materials and subjects, these results suggest use of MC and list formats, both of which require considerably less time in program development, should be carefully considered prior to implementation of constructed response modes.

Comparisions of the results of this study with the copious Einstellung literature must be tempered by two considerations. First, the method of display and responding in this study was via interactive computer terminals rather than by typical paper and pencil. Second, the criterion for inclusion of subjects was modified in this study. In the prototypical water jar problems, the participant had to solve both items 5 and 6 via the Einstellung method to

assure that set had in fact been established. Data from those who did not respond in such a manner was discarded. In the present study, subjects who solved item 5 or 6 by the E method were included. Adhering to the previous standard would have resulted in collection of data for N's of List-3, CR-7, Code-11 and MC-14, rather than N7s used consisting of 18, 18, 18 and 19 per group. This may indicate that in initial susceptibility to set, those in the List mode would be most immune. followed closely by CR. Based on these standards, MC demonstrated greatest susceptibility as hypothesized.

1
Joan M. Sustik
Research Investigator
CAI Laboratory

229 LCM
University of Iowa
Iowa City, Iowa 52240

Bobby R. Brown
Director, CAI Laboratory
Associate Professor Educational Psychology and Associate Professor Instructional Design and Technology
229 LCM
University of Iowa
Iowa City, Iowa 52240

2
Special thanks and recognition to Ron Roskam for his assistance in the development of the computer based materials and to Mike Valiga for his assistance in data analysis.

3

The data obtained in this experiment were analyzed using a Split-Plot (Lindquist Type-I) analysis of variance design. In this study the four treatment groups (List, Multiple Choice, Code and Constructed Response) provided the between-subject factor, and the two "Extinction" or the four "Critical" problems represented the within subject factor. Separate analysis were conducted for the Extinction problems and for the Critical problems. In both cases four dependent measures were considered (again in a separate split-plot analysis): time to the first response on a given problem, total time spent in the problem, total number of steps in used in the problem, and number of E or D type solutions used.

Prior to analysis, the data were examined to determine whether the assumptions of the analysis of variance model had been met. Two problems were readily apparant, the dat (especially on the time data) exhibited noticeable positive skewness, and the data also displayed marked heterogenaity of variance. The skewness (non-normality) was judged to present relatively minor problems since the F-ratio test has been shown to be quite robust to violations of this assumption. The heterogenaity of variance however, was judged to be far more critical especially since the numbers in the treatment group were unequal (see Box 1954). Considering these limitations, a standard split-plot ANOVA was judged to be unsuitable.

To overcome these violations of assumptions, two corrective statistical procedures were employed in conjunction with the overall split plot design. In all comparisons involving the between-subjectsfactor, the statistic V proposed by Welch (1951) was used as an alternative to the between-group F test. This statistic was choden since it allows unequal group sizes, and takes into account heterogenaity of variance within the treatment groups. The statistic is computed using the sample means, the unbiased estimates of the treatment groups' variances, the sample sizes, and the number of treatment groups involved. Welch demonstrated that under the null hypothesis the distribution of this statistic could be approximated by a central F distribution. In many cases this alternate statistic provided less significant results than did the conventional ANOVA, but in several instances it yielded F values which were noticeably more significant than those of the conventional test. In ALL cases, however, this test was more appropriate due to the nature of the sample data.

In all comparisons involving the within-subject factor, the F test obtained from the split-plot ANOVA was modified using a technique proposed by Geiser and Greenhouse (1958). This technique involves adjusting the two degrees of freedom values of the F-ration by the multiplicative factor $\varepsilon (\leq 1.0)$ This correction reduces the values of the two degrees of freedom whenever the sample variances within the treatments are unequal or when the correlations between the measures under all pairs of treatments are unequal. While this statistic tends to be somewhat conservative (see HuynH and Feldt, 1976), the nature of the sample variance-covariance matrix obtained, in addition to the skewness of the data necessitated the use of this corrected F-ratio. The corrected tests discussed in the previous paragraphs were used in all of the initial tests, the follow-up tests, and the pairwise comparisons used in this study.

TABLE 2

INPUT COMMANDS FOR LIST AND CODE RESPONSE MODES

LIST	CODE	COMMAND
1	FA	Fill Jar A
2	FB	Fill Jar B
3	FC	Fill Jar C
4	AIB	Pour the contents of A into B
5	AIC	Pour the contents of A into C
6	BIA	Pour the contents of B into A
7	BIC	Pour the contents of B into C
8	CIA	Pour the contents of C into A
9	CIB	Pour the contents of C into B
10	EA	Empty Jar A
11	EB	Empty Jar B
12	EC	Empty Jar C
13	SA	Solution is in Jar A
14	SB	Solution is in Jar B
15	SC	Solution is in Jar C
16	NS	No Solution

TABLE 1

PROBLEM SERIES USED

PROBLEM #	PROBLEM	SOLUTIONS*	TYPE
1	11-25-5 get 4	E	set
2	21-127-3 get 100	E	set
3	14-163-25 get 99	E	set
4	18-43-10 get 5	E	set
5	9-42-6 get 21	E	set
6	20-59-4 get 31	E	set
7	23-49-3 get 20	E or D	critical
8	15-39-3 get 18	E or D	critical
9	28-76-3 get 25	D	extinction
10	18-48-4 get 22	E or D	critical
11	14-36-8 get 6	E or D	critical
12	6-21-4 get 7	E	set
13	40-118-18 get 62	D	extinction

* E indicates Einstellung Method
D indicates Direct Method

TABLE 3

FORMATION OF SET IN CRITICAL PROBLEMS AND ABILITY TO OVERCOME SET IN EXTINCTION PROBLEMS

	SUSCEPTIBILITY TO SET IN CRITICALS			
GROUP	7	8	10	11
Code	.43(.99)	.37(.48)	.25(.43)	.12(.33)
Multiple Choice	.72(.44)	.16(.37)	-0-	-0-
List	.25(.43)	.25(.43)	.25(.43)	.12(.33)
Constructed Response	.14(.34)	.28(.45)	.14(.34)	.14(.34)

	ABILITY TO OVERCOME SET IN EXTINCTIONS	
GROUP	9	13
Code	.93(.24)	.18(.38)
Multiple Choice	1.00(0)	.77(.41)
List	1.00(0)	.37(.48)
Constructed Reponse	1.00(0)	.42(.49)

Note: Scale in criticals represents mean number of E-type solutions
Scale in extinctions represents mean number of D-type solutions
Numbers in parenthesis indicate standard deviations

TABLE 4

MEAN TIME IN SECONDS FOR TIME TO FIRST RESPONSE

AND TOTAL TIME IN PROBLEM

CRITICAL PROBLEMS - LATENCY

GROUP	7	8	10	11
Code	10.18(6.30)	12.68(6.91)	11.12(7.14)	20.25(16.53)
Multiple Choice	22.27(9.83)	18.55(8.24)	10.55(8.80)	13.61(9.89)
List	12.37(5.36)	11.6 (5.98)	13.18(8.19)	14.87(11.59)
Constructed Response	14.64(11.12)	17.00(8.61)	12.72(7.14)	31.07(28.66)

EXTINCTION PROBLEMS - LATENCY

GROUP	9	13
Code	16.06(18.70)	48.37(47.94)
Multiple Choice	18.61(16.18)	51.38(26.21)
List	29.75(61.08)	78.00(82.23)
Constructed Response	14.50(12.06)	54.21(42.97)

CRITICAL PROBLEMS - TOTAL TIME

GROUP	7	8	10	11
Code	36.93(25.70)	42.25(14.00)	57.43(40.38)	64.12(57.12)
Multiple Choice	24.50(10.75)	20.55(8.34)	12.27(8.95)	22.33(29.27)
List	38.62(14.30)	48.56(15.15)	43.68(14.50)	45.50(35.09)
Constructed Response	98.35(20.77)	108.85(66.69)	72.71(25.21)	75.57(25.21)

EXTINCTION PROBLEMS - TOTAL TIME

GROUP	9	13
Code	76.37(110.39)	107.68(126.76)
Multiple Choice	23.88(18.00)	53.83(27.30)
List	77.31(116.83)	166.87(89.14)
Constructed Response	53.57(31.75)	324.92(347.58)

TABLE 5

MEAN NUMBER OF STEPS USED BY CODE, LIST AND CONSTRUCTED RESPONSE RESPONSE MODE GROUPS

	CRITICAL PROBLEMS			
GROUP	7	8	10	11
CODE	4.75(1.78)	5.87(1.40)	6.87(3.46)	5.00(2.62)
LIST	4.25(1.43)	5.81(.94)	5.50(0.93)	5.12(4.28)
CONSTRUCTED RESPONSE	3.71(1.09)	7.42(3.28)	5.92(0.88)	4.57(3.31)

	EXTINCTION PROBLEMS	
GROUP	9	13
CODE	4.93(4.58)	9.87(9.49)
LIST	4.68(2.11)	7.87(5.38)
CONSTRUCTED RESPONSE	3.78(1.47)	11.50(12.24)

NOTE: Numbers in parenthesis indicate standard deviations

TABLE 6

ANALYSIS OF VARIANCE OF E-TYPE SOLUTIONS IN CRITICAL PROBLEMS

SOURCE	DF1	DF2	F	SIGNIFICANCE
MODE	3	30.72	.40	
ITEM	2.76	165.87	10.26	.000006
ITEM X MODE	8.29	165.87	3.84	.000329

TABLE 7

ANALYSIS OF VARIANCE OF D-TYPE SOLUTIONS IN EXTINCTION PROBLEMS

SOURCE	DF1	DF2	F	SIGNFICANCE
MODE	3	27.24	.05	.980000
ITEM	1	60	81.54	.000000
ITEM X MODE	3	60	3.98	.011779

TABLE 8

ANALYSIS OF VARIANCE FOR TIME TO FIRST RESPONSE FOR CRITICAL PROBLEMS

SOURCE	DF1	DF2	F	SIGNIFICANCE
MODE	3	31.216	1.66	
ITEM	1.83	110.068	6.22	.003589
ITEM X MODE	5.50	110.068	4.03	.001515

TABLE 9

ANALYSIS OF VARIANCE FOR TIME TO FIRST RESPONSE IN EXTINCTION PROBLEMS

SOURCE	DF1	DF2	F	SIGNIFICANCE
MODE	3	30.83	.533	.662978
ITEM	1	60	30.420	.000001
ITEM X MODE	3	60	.300	.826000

TABLE 10

ANALYSIS OF VARIANCE FOR TOTAL TIME IN PROBLEM FOR CRITICAL PROBLEMS

SOURCE	DF1	DF2	F	SIGNIFICANCE
MODE	3	29.10	30.225	
ITEM	2.24	134.21	3.260	.036044
ITEM X MODE	6.71	134.21	2.950	.00748

TABLE 11

ANALYSIS OF VARIANCE FOR TOTAL TIME IN PROBLEM FOR EXTINCTION PROBLEMS

SOURCE	DF1	DF2	F	SIGNFICANCE
MODE	3	25.15	14.26	
ITEM	1	60	21.93	.000017
ITEM X MODE	3	60	3.96	.012154

TABLE 12

ANALYSIS OF VARIANCE OF TOTAL STEPS IN CRITICAL PROBLEMS

SOURCE	DF1	DF2	F	Significance
MODE	2.00	28.38	.413	665173
ITEM	2.29	98.53	7.69	.000441
ITEM X MODE	4.58	98.53	1.28	.282523

TABLE 13

ANALYSIS OF VARIANCE FOR TOTAL STEPS IN EXTINCTION PROBLEMS

SOURCE	DF1	DF2	F	SIGNIFICANCE
MODE	2	24.24	.409	.668783
ITEM	1	43.00	12.950	.000822
ITEM X MODE	2	43.00	.81	.450719

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